Emerging Materials Research
Volume 4 Issue EMR2
Editorial
Ravindra

Emerging Materials Research
December 2015 Issue EMR2
Pages 189–191 http://dx.doi.org/10.1680/jemmr.2015.4.2.189

ice | science

ice
Institution of Civil Engineers
publishing

Editorial

Nuggehalli M. Ravindra PhD
New Jersey Institute of Technology, Newark, NJ, USA

The 25th Workshop on Crystalline Silicon Solar Cells and Modules: Materials and Processes was held this year on 26–29 July 2015 in Keystone, CO, USA (see http://www.siliconworkshop.com). Since the inception of the first workshop[1] in August 1990, the focus of the workshop has shifted from the 'Role of point defects/defect complexes in silicon device fabrication' to 'Advanced diagnostics, heterojunction solar cells and advanced industrial solar cells'. The highlights of the Workshop included the following presentations and discussions: *The Importance of Hydrogen Passivation, A Recurrent Topic In The Workshop For 25 years* by Giso Hahn of the University of Konstanz, Germany; *Silicon Wafer Cleaning Technology* by John Joachim, IMEC, Belgium; and *Levelized Cost of Electricity (LCOE) – Advantages of Efficiency* by Paul Basore of the National Renewable Energy Laboratory. The US Department of Energy (DOE) SunShot Initiative is now in its fourth year. By bringing together the various sectors of the solar cell community including companies, national labs, universities, and local and state governments, the goal of this collaborative effort is for solar-generated power to be cost-competitive with other non-renewable forms of electricity, without incentives, by the year 2020 (see http://energy.gov/eere/sunshot/sunshot-initiative). With the significant level of commitment, dedication, partnership, support and team effort from the US DOE, the National Renewable Energy Laboratory and the photovoltaics community, this ambitious program should succeed and result in increased manufacture and use of solar cells across the USA and beyond.

The solar cell industry has attracted new material candidates in recent years. This includes the perovskites.[2] Perovskite solar cell efficiencies have increased from 3–4% in 2009[3] to ~20% in 2014.[4] The recent successful demonstration of room temperature single-photon emission from individual perovskite quantum dots by Park *et al*.[5] will lead to expeditious transition of perovskites from fundamental research and development to manufacturing of perovskite-based optoelectronic devices.

'Crystal structures of aluminum-based hydrides'[6] – the paper by Vajeeston and Fjellvåg of the Department of Chemistry, Center for Materials Sciences and Nanotechnology, University of Oslo, Blindern, Oslo, Norway – was presented at the International Conference on Sustainable Energy Technologies (ICSET) 2014 (see http://www.icset.ex.ac.uk). The interest in hydrogen is because of the following: it represents a clean form of energy; it is a most abundant element in the universe; it is the lightest fuel; it is richest in energy per unit mass; and unlike electricity, it can be easily stored. Hydrogen gas is the most promising fuel for various applications. Hydrogen is already being used as the fuel of choice for space programs around the world. Metal hydrides are a fascinating class of compounds because the small mass and size of hydrogen and its medium electronegativity causes a large flexibility in terms of metal–ligand interactions. These manifest in a vast variety of possible compositions, chemical bonding, crystal structures and physical properties. In this review, the authors present the structural details of all aluminum-based hydrides known to date.

The next paper[7] in this issue focuses on the 'Selective preference of engineered peptides for aluminum alloy'. In this paper by Adams and Stratis-Cullum of the US Army Research Laboratory, Adelphi, Maryland, USA, the authors discuss bacterial cell-surface display technology as a powerful tool for the discovery and study of peptide material interactions offering the potential toward tailoring the interaction and tuning the properties of multicomponent materials for future military and commercial systems. With bacterial cell-surface display technology, a large diverse library containing billions of peptide material variants is encoded directly into the bacterial DNA, resulting in a self-sustaining and self-replicating population that can easily be propagated without requiring elution from the target. Recently, this method was extended to genetically engineered peptides for inorganics, specifically to a bulk aluminum alloy. In this paper, the authors investigate the binding interaction of this peptide material including a study of relative binding to aluminum, glass, copper and brass. The surface display peptide exhibited more than two orders of magnitude greater binding to the aluminum alloy compared with the glass sample, and little to no interaction with copper and brass. These results highlight, for the first time, the potential for selection interaction of genetically engineered peptides using the eCPX construct with inorganic materials, and open the possibility for bio-hybrid materials and systems of the future.

'Characteristics of micro-arc oxidation and laser melting modified compound film on Ti alloy surface' by Wang *et al*. of the School of Mechanical Engineering, Dalian University of Technology, Dalian, P. R. China, is the next paper[8] in this issue of *Emerging Materials Research.* This paper reports a study on the preparation and performance of films with porous microstructure through the micro-arc oxidation (MAO) process on TC4 alloy (Ti-6Al-4V) surface and the laser remelting (LSM) process. Two kinds of specimens were fabricated: one was prepared only using the MAO process in a silicate electrolyte system; the other was treated using the LSM process after MAO. Then, subsequently, MAO and MAO+LSM films were fabricated. Scanning electron microscopy, X-ray diffraction, ultra microhardness tester and electrochemical analyzer were used to analyze the microstructure, phase composition, surface hardness and corrosion resistance of two kinds of films. The results show that the film, after LSM from inside to outside, exhibits a dense layer, a middle layer and a remelting layer; the former MAO loose layer is replaced by the remelting layer with a compact structure and low porosity. As well as the proportion of rutile phase in MAO+LSM film being improved, the hardness and corrosion resistance is also increased, and the combination mode of MAO film and the substrate is maintained. Therefore, for improving the properties of MAO film on the Ti alloy surface, LSM technology plays a promoting role.

In the next paper[9] presented in this issue of *Emerging Materials Research*, Bhuyian and Misra of the Department of Electrical and Computer Engineering, New Jersey Institute of Technology, Newark, NJ, USA, report their studies on the reliability of atomic layer deposited (ALD) $Hf_{0.2}Zr_{0.8}O_2$ and HfO_2 on a SiON interfacial layer with DADA[1] (cyclic deposition and annealing) and DSDS[2] (cyclic deposition and slot plane antenna (SPA) argon plasma exposure). The results are compared with control (i.e. as-deposited samples) without any treatment during or after the dielectric deposition. DSDS $Hf_{0.2}Zr_{0.8}O_2$ demonstrates a promising equivalent oxide thickness (EOT) downscaling ability, a reduced gate leakage current, and low mid-gap interface state density as compared to the control device, while DADA $Hf_{0.2}Zr_{0.8}O_2$ has degraded the value of EOT as well as the interface. When devices are subjected to a constant voltage stress in the gate injection mode, DSDS $Hf_{0.2}Zr_{0.8}O_2$ showed a four-times greater reduction in the flat-band voltage shift and a three orders of magnitude reduction in the stress-induced leakage current within 100 s stress as compared to the control sample. The observed time to failure, T63%, is the highest for DSDS $Hf_{0.2}Zr_{0.8}O_2$. The addition of zirconium and the cyclic plasma exposure (DSDS process) seems to suppress the oxide trap formation in $Hf_{0.2}Zr_{0.8}O_2$ films. When DSDS $Hf_{0.2}Zr_{0.8}O_2$ is deposited on two different interfacial layers, SiON and plasma oxynitride are compared; SiON demonstrates improved reliability compared to plasma oxynitride.

Basnyat *et al*. report their 'Experimental study to separate surface and bulk contributions of light induced degradation in crystalline silicon solar cells'.[10] This study is a collaborative effort between the National Renewable Energy Laboratory, Golden, CO, the New Jersey Institute of Technology, Newark, NJ, SunEdison, Portland, OR and SunEdison, St Peters, MO, USA. In this paper, investigations toward understanding the bulk and surface components of light-induced degradation (LID) in low-Fe c-Si solar cells is explored. The bulk effects, arising from boron–oxygen defects, are determined by comparing the degradation of cell parameters and their thermal recovery with that of the minority-carrier lifetime in sister wafers. It is found that the lifetime of wafer is recovered fully after annealing but cell efficiency is only recovered partially. It is also shown that cells that have a SiN:H coating experience surface degradation (ascribed to surface recombination). The surface LID is seen as an increase in the q/2kT component of the dark saturation current (J_{02}). The surface LID does not recover fully upon annealing and is attributed to the degradation linked to the SiN:H–Si interface. This behavior is also exhibited by mc-Si cells that have very low oxygen content and do not show any bulk degradation.

The next paper[11] in this issue is a study of 'Comparative investigation on performance of various aspiration methods applied in a single cylinder diesel engine'. This research, presented at ICSET 2014, is a collaborative effort between the Department of Mechanical Engineering, the Adithya Institute of Technology and the Department of Mechanical Engineering, JCT College of Engineering and Technology, Coimbatore, India. Duraiswamy, Guru and Madakkan investigate the effects of various aspiration methods such as natural aspiration, charge preheating, exhaust gas recirculation and supercharging on the performance of a diesel engine using neat diesel fuel in terms of brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, specific fuel consumption and total fuel consumption. For this study, a naturally aspirated four-stroke single cylinder diesel engine was modified and tested with diesel fuel under various load conditions. The evaluation of the experimental data showed that supercharging the engine gives a more comparative performance than all other aspiration methods considered in this work.

The participation and support of the organizers of ICSET 2014 and The 25th Workshop on Crystalline Silicon Solar Cells and Modules: Materials and Processes is acknowledged with thanks.

REFERENCES

1. Solar Energy Research Institute. *Book of Abstracts, SERI Workshop on the Role of Point Defects/Defect Complexes in Silicon Device Fabrication*, August 30–31, 1990, Keystone, CO, USA. See http://www.nrel.gov/docs/legosti/old/3976.pdf for further details. Accessed 10/09/2015.
2. Green, M. A.; Ho-Baillie, A.; Snaith, H. J. The emergence of perovskite solar cells. *Nature Photonics* **2014**, *8*, 506–514.
3. Kojima, A.; Teshima, K.; Shirai, Y.; Miyasaka, T. Organometal halide perovskites as visible-light sensitizers for photovoltaic cells. *Journal of the American Chemical Society* **2009**, *131*, 6050–6051.
4. Zhou, H.; Chen, Q.; Li, G.; Luo, S.; Song, T-b.; Duan, H-S.; Hong, Z.; You, J.; Liu, Y.; Yang, Y. Interface engineering of highly efficient perovskite solar cells. *Science* **2014**, *345*, 542–546.
5. Park, Y-S.; Guo, S.; Makarov, N.; Klimov, V. I. Room temperature single-photon emission from individual perovskite quantum dots. *ACS Nano* **2015**, doi: 10.1021/acsnano.5b04584.
6. Vajeeston, P.; Fjellvåg, H. Crystal structures of aluminum-based hydrides. *Emerging Materials Research* **2015**, *4*, 192–217.

7. Adams, B. L.; Stratis-Cullum, D. N. Selective preference of engineered peptides for aluminum alloy. *Emerging Materials Research* **2015**, *4*, 218–222.
8. Wang, F.; Wang, Y.; Hou, B.; Liu, H.; Lian, M. Characteristics of micro-arc oxidation and laser melting modified compound film on Ti alloy surface. *Emerging Materials Research* **2015**, *4*, 223–228.
9. Bhuyian, M. N. U.; Misra, D. ALD $Hf_{0.2}Zr_{0.8}O_2$ and HfO_2 with cyclic annealing/SPA plasma treatment: reliability. *Emerging Materials Research* **2015**, *4*, 229–238.
10. Basnyat, P.; Sopori, B.; Devayajanam, S.; Shet, S.; Binns, J.; Appel, J.; Ravindra, N. M. Experimental study to separate surface and bulk contributions of light-induced degradation in crystalline silicon solar cells. *Emerging Materials Research* **2015**, *4*, 239–246.
11. Duraiswamy, P.; Guru, R.; Makaddan, V. Comparative investigation on performance of various aspiration methods applied in a single cylinder diesel engine. *Emerging Materials Research* **2015**, *4*, 247–252.